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Eye Blink Detection and Extraction in EEG Signals Using EMD asnd ICA Techniques

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Abstract *— Eye-blink is the major source of artifact in the electroencephalogram (EEG) recorded signals. The extracted signal is contaminated by one process called Electro Oculo Gram (EOG). Wavelet based technique is used suppress the contaminated signal and other method is used as data driven technique is called empirical mode decomposition with cross-correlation. EMD extracts the signals without any reference electrode and decomposes the non-stationary signals into series of IMF's (Intrinsic Mode Functions) , the IMF's are associated with ocular artifact then it is termed as noisy IMF. Other different techniques also used to suppress the ocular artifact and correction of EOG. ICA, PCA, Regression methods are used to suppress the artifact. The received signal is must be in single channel.*

Keywords- Ocular artifact, Electroencephalogram(EEG), empirical mode decomposition(EMD), intrinsic functions, cross-correlation, independent component analysis (ICA).

I.INTRODUCTION

EEG signals are in the form of electrical signal captured by electrodes. These electrodes receives EEG signal from the brain, eye blink signal from eyes. These two signals are combines together and forms contaminated signal. Noise also added in this contaminates the signal. The EEG signal associated with eye blink is called as artifact, it associates with noise is called as noisy signal. There are different methods are used to overcome this problems. Electrodes placed on the scalp and near to the eyes for eye blink measurement, electrodes are placed to the heart it measures heart problems. Wavelet based technique is used to suppress the eye blink other different methods are ICA, PCA, regression method is used for the suppress the eye blink from the EEG signal. After suppressing the eye blink signal cleaned signal eye blink signal gets separately. Empirical mode decomposition is also one important method for suppression of contaminated signal into residue signal. Empirical mode decomposition decomposes the original signal or input signal into different IMF's.

II. LITERATURE SURVEY

Eye blink and eye movement are the artifact in the recorded EEG signal. The eye which consists of electrical dipole and sight of eye changes due to the eye movement and eye blink and also which causes change over the scalp. One approach is used for analysis and suppression of artifact is wavelet based technique. The other technique also used which effectively suppress the artifact is data driven technique is called empirical mode decomposition (EMD) with cross correlation.

The EEG recorded EEG signal is contaminated this process is called electro ocular gram (EOG). The contaminated EEG signal is decomposed into a series of intrinsic mode function(IMF's), if the some IMF's are associated with artifact then it is termed as noisy IMF's. The other different techniques are used to suppress the artifact which is produced by eye movement and blink as well as contaminated by EOG are JADE (joint approximation Diagonaliging of Eigen matrices), extended ICA (independent component analysis), PCA (principle component analysis) and subtraction EOG, regression method and wavelet based technique, EMD. The JADE and ICA are subjected to amplitude scaling and permutation, these two are more effectively removes the artifact from EEG signal than subtraction EOG and PCA. PCA and ICA are used in artifact rejection problem.

PCA finds the set of orthogonal components maximizing the variance and ICA performs signal separation into independent components by maximizing the measurement of non guassianity from this problems occurs in ICA. The main problem of this ICA separate the signals into independent from this which creates problem. PCA and ICA requires multichannel EEG data. Subtraction EOG causes the attenuation in the EEG waveform. Wavelet based technique which analyses and suppress the artifact from single channel EEG data. Regression method which is used in ICA as ICA

regression method . The normal regression method is based on to remove the artifact from EEG signal, but this method might produce unexpected distortion in the data hence comparing to regression method ICA regression method.

III. METHODOLOGY

A)Block Diagram:

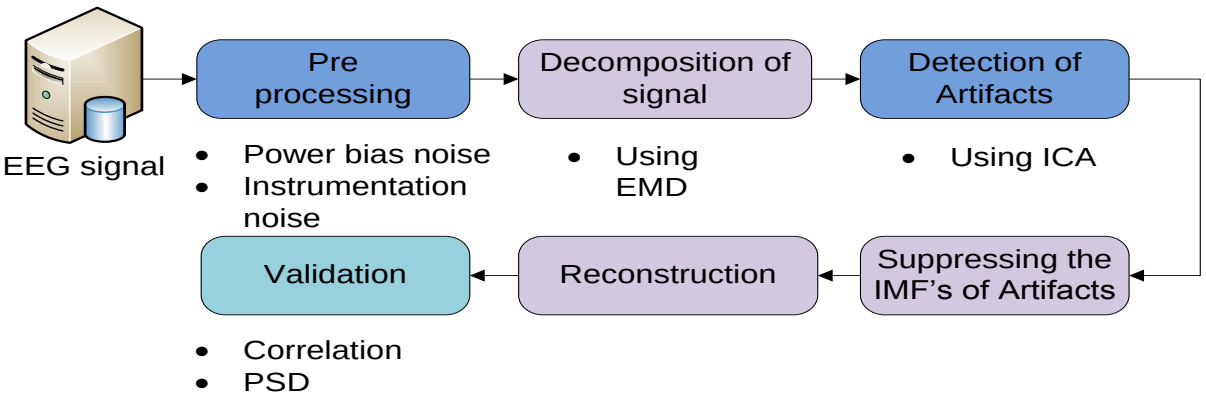

Figure 1. Architectural Block Diagram of Enhanced model

The existing method uses EEG as input which is decomposed using Empirical Mode Decomposition (EMD). sThe decomposition technique is based on direct extraction of the signal energy or it can be stored in any other memory space to use immediately or future time which is associated with various intrinsic time scales. The technique adaptively decomposes non-stationary signals into a set of intrinsic oscillatory modes termed as Intrinsic Mode Functions (IMFs). These IMFs represent signal components, which vary from those with high frequencies to those with low frequencies. The EMF features which capture features of eye blink will be considered as noisy IMF's. Using Cross correlation these are eliminated.

Artifact Detection Measures like variance and skewness for identification of the eye-blink artifact by setting the threshold. An Artifact Suppression Algorithm is used to selectively suppress the artifact without much affecting the signal from the brain. In order to ensure that the extracted ocular artifact from the contaminated EEG data contains less cerebral and more eye-blink activity, calculated the Root Mean Square Error (RMSE) as well as the change in the Power Spectral Density.

Cross-correlation coefficient was evaluated between each extracted template from the IMFs and the corresponding artifact contaminated EEG segment. IMFs were arranged in a sequence starting from the best match (highest cross correlation) to the worst match (lowest cross-correlation) with the contaminated EEG signal. If the correlation coefficient was higher than a preset threshold, then that particular IMF was discarded as the technique relies on rejection of all noisy IMFs. Significance of this method lies in the fact that it is easy to use and enables automated suppression of ocular artifacts from the contaminated EEG recording. The architecture Block Diagram of this existing methodology is as shown in figure 2.

In pre processing the records which are taken from the electrodes impose some amount of irrelevant noise contents in EEG data signals. The noise may be power biased noise and instrumentation noise. These noises are to be eliminated in pre processing itself before decomposition. The EMD technique is used to decompose the EEG signals into IMF's. The IMF's with eye blink signals are known as noisy IMF's those have to be removed using ICA. Independent component analysis (ICA) is used for the detection of the artifacts due to eye blink. Correlation is performed between extracted signal and original signal for validation.

B) Data flow of the model:

Data flow of this project mainly consists of different steps for processing , this selects the query or data set, removing the noise, decomposition of signal into different IMF's, eye blink detection-extraction and suppression by ICA (Independent Component Analysis). Suppression of eye blink by ICA depends on the frame, and reconstructing the input signal into separate cleaned EEG signal and eye blink extracted signal.

The first process in this data flow is selecting the query or data set that is stored for further processing. The data set is extracted from electrodes or EEG cap. The electrodes are placed on the brain as well as electrodes placed near to the eyes. The electrodes placed on the brain extracts EEG signal, while near to the eyes extracts eye blinking signal. These two eye blinking signal and EEG signal from the brain combines together and forms contaminated EEG signal or it

is called as EEG signal with eye blink. This contaminated signal is stored in the CPU or any other memory space or it can be used at the time of processing.

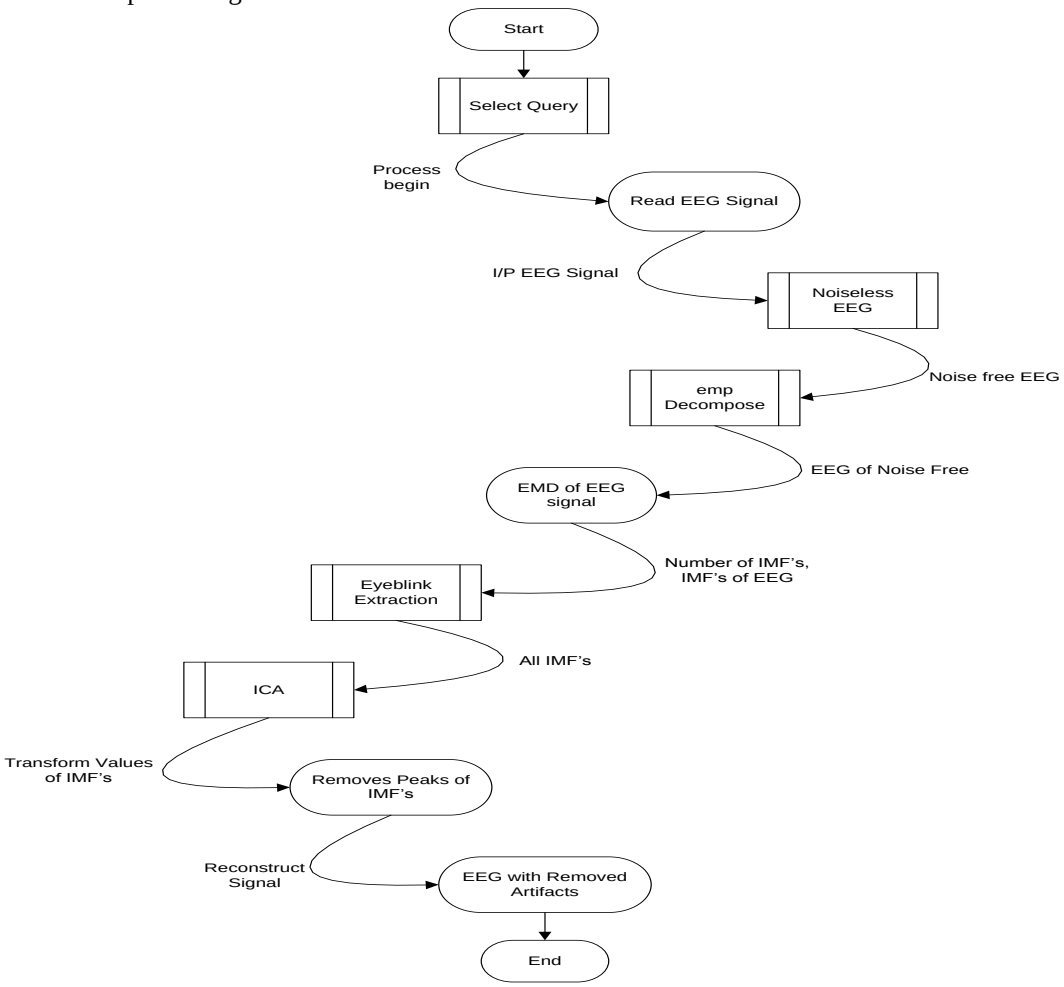

Fig 2.Data flow diagram

The second process is noisy EEG signal to noiseless EEG signal. In this it consists of eye blink ,EEG signal and different types of noise. This noise are added with eye blink and EEG signal are called as noisy signal. The different noises are sad, laugh, thinking, emotional feel creating in our mind. The person is in the normal stage, then there is no noise with EEG signal. EEG signal connected with eye blink are called as artifact. EEG signal associated with noise are called as noisy signal. This noisy signal along with contaminated signal is between 2150 to 4000 range. The signal is set into zero by applying polynomial curve fit for the signal, it shifts to zero then by applying butter worth filter the signal becomes smooth and noise is removed by smoothing. Now it only contains eye blink signal and EEG signal.

The third process and last process is decomposition which decomposes the noiseless EEG signal into different IMF's, IMF1, IMF2……IMF'n. In this each IMF is compared with input signal, if this signal is similar to input signal, then it is pass through the next step. In the next step eye blink detecting and extracting is done by ICA. The further step is reconstructing signal, in this reconstructing signal it finds input signal which contains EEG signal and cleaned signal it completely removes noise and artifact. This is called cleaned EEG signal and eye blink is separately extracted.

IV. IMPLEMENTATION

A)EEG input signal:

In this project there are of different steps for processing and simulation. In this section first is consider as repeat function which executes repeatedly one by one process, will considered as repeat is equal to one otherwise it to stop that repeating same process we have to give repeat as zero. In this project different cases are followed for performing the process. First case is considered as selects the query of EEG signal from data set and removing the noise and making noiseless EEG signal. Second case considered as after removing noise from signal decomposition of EEG signal into 'n' number of IMF's performs. Third case considered as after decomposition will compare each IMF with original signal, which is similar to original signal that will pass through ICA for detecting eye blink then extracting that

eye blink and then suppressing of eye blink has been done. Forth case is considered as result will get as corrected and cleaned EEG signal and separated eye blink and plotted as a graph.

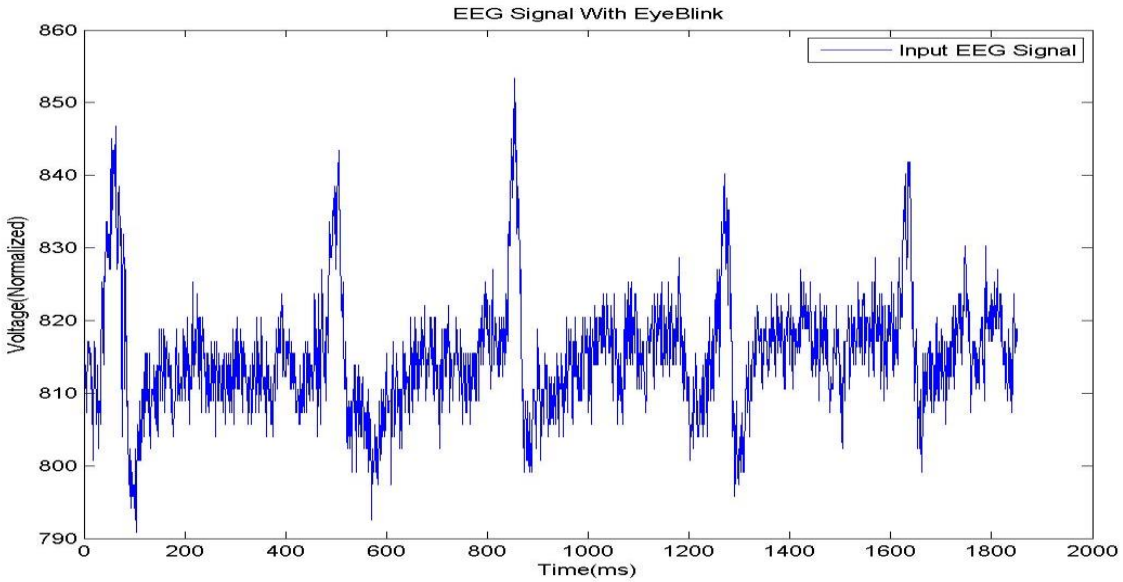

Figure 3. Input Signal of EEG

B)Noisy signal to noiseless signal:

Noiseless EEG filters out the noise component from the EEG signal using Butterworth 10^{th} order filter. Butterworth filter is considered only up to 10^{th} order because increased order will reduces the EEG signal as normalized(smoothed) and when it reaches to the zero value then there is no proper EEG signal available. If the filter is in the 10^{th} order or less, the EEG signal and noise signal will be in low frequency where as eye blink is in high frequency.

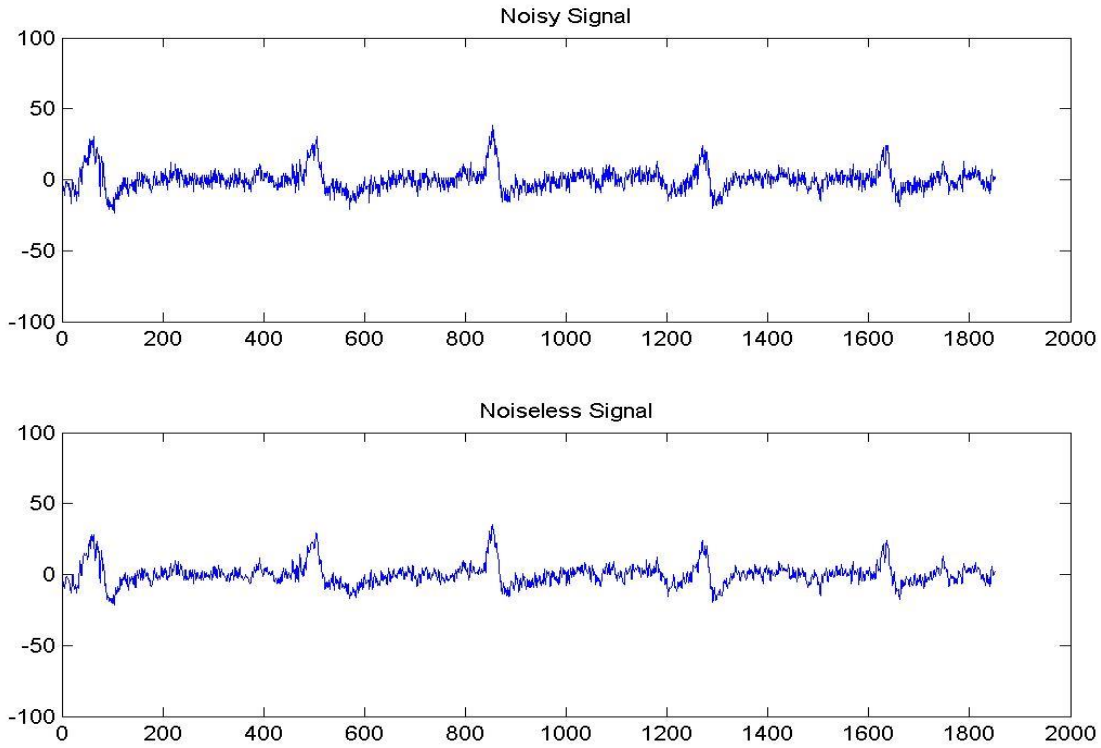

Fig 4. Noisy signal to noiseless signal

C)Decomposition of signal into 10 IMF's:

Empirical mode decomposition, decomposes the input signal into n successive IMF. For loop is used to decompose the input signal into n successive IMF. After getting the loop on successive IMF, which checks the each IMF with input signal. IMF is relatively matched to the input signal that signal is passed to perform ICA(Independent Component Analysis).

Empirical Mode Decomposition (EMD) which directly extracts data values from the brain or data values are stored in CPU. The direct extracted signal energy is associated with various intrinsic time scale. The decomposition technique which adaptive decomposes the non stationary signal into set of intrinsic oscillatory mode, it is called as intrinsic mode function (IMF). The IMF is associated with artifact then it is termed as noisy IMF.

IMF represents as a signal component which vary the high frequency to low frequency. The input signal consists of both EEG signal as well as eye blink signal, eye blink signal is higher frequency than EEG signal. In EMD we have to apply for the data set then all extreme in the data are identified as upper and lower envelope by using cubic spline interpolation. The mean of upper and lower envelope are calculated. In this input signal is identified as 'x', and mean of upper and lower envelope is identified by 'a'. Both input signal and mean of envelope is calculated to get 'h'.

$$a(t)=x \qquad (1)$$

The 'h' is identified as difference, if this difference satisfies the two condition then residue signal is obtains. The two conditions are,

- **Condition 1:** X(t)'s number of extreme and number of zero crossings is either equal or differ at most by one.
- **Condition 2:** At any point the mean value of the envelope is defined by local maxima and local minima is zero.

$$h(t)=x(t)-a(t) \qquad (2)$$

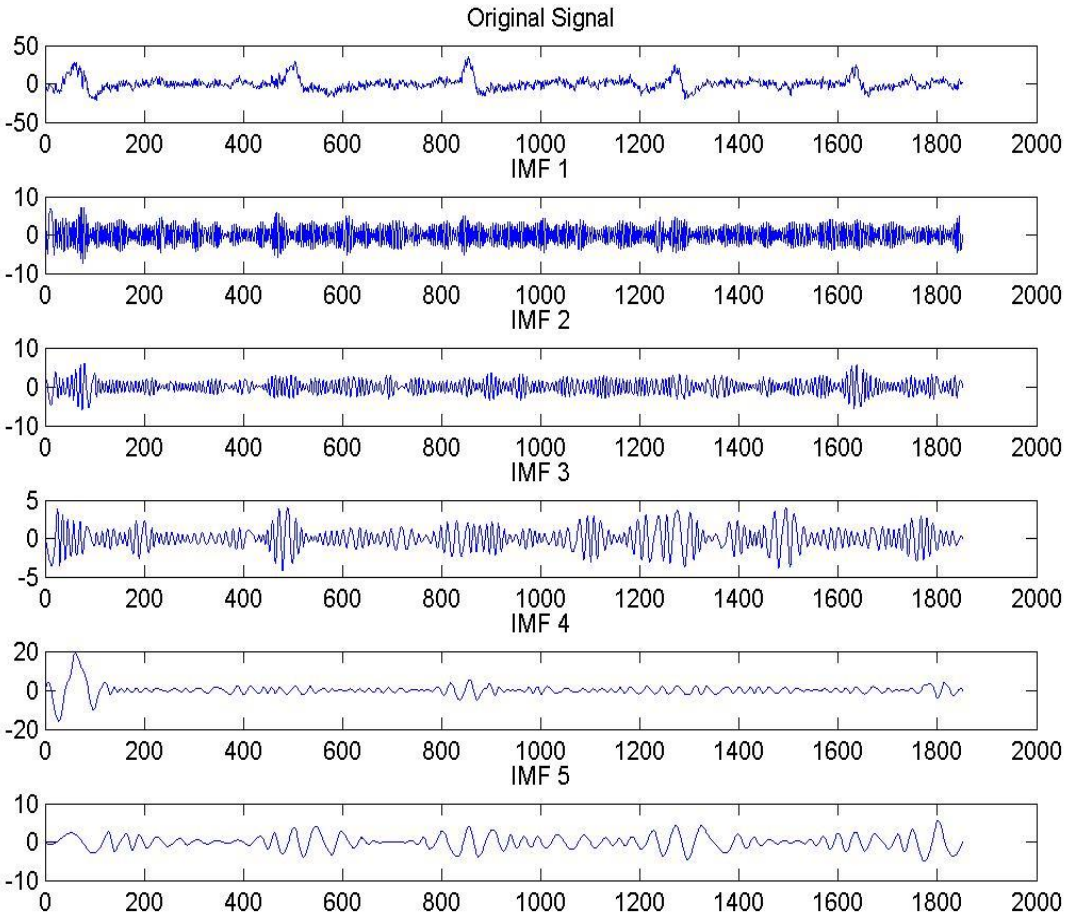

Fig 5. Decomposed signal for first 5 IMF.

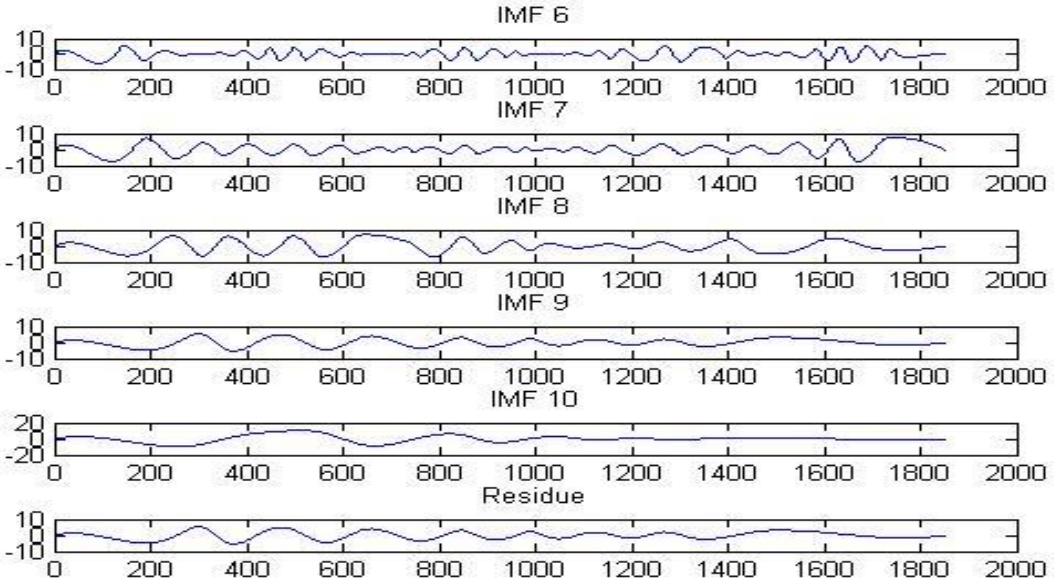

Fig 6. Decomposed signal for next 5 IMF.

The both conditions are satisfies IMF1 is considered as residue signal as well as similar to the input signal, otherwise the process continues for other IMF till the difference satisfies the IMF condition.

At the beginning sifting process is used and considered h is input signal. Typical standard deviation SD>0.3, if SD<0.3 then IMF condition is not satisfied. Standard deviation repeats the same process till it get more than 0.3, then it satisfies the IMF. After satisfying the IMF condition which finds the local max/min points to get approximate derivative, then divide maxmin into max and min . Both max and min makes end points. To get max and min envelopes from IMF spline interpolation is used. After getting max and min envelope, mean of max and min envelopes is calculated. Then mean value is subtracted from input signal then exact IMF is extracted from the signal, store the extracted IMF in the matrix IMF. The calculation of standard deviation is used to avoid zero values.

D)ICA (Independent Component Analysis) is used to suppress eye blink:

ICA which is used to suppress the eye blink passed from IMF, by checking the presence of eye blink sample signals are extracted from original signal which represents exact eye blink in the dataset. The received signal consists of different frames which starts from frame1size to end frame 1600. The data values which contains eye blink, will be checked from value zero to see where the eye blink is found. If the same is started from 400 or 500 value it is difficult to find. After getting the eye blink we have to set signal as one fixed threshold value as mean, if the signal crosses that threshold value then that signal is identified as eye blink, the remaining signals available as up to the threshold set or less than threshold that signal is identified as EEG signal. using ICA method eye blink is detected from the signal, using some filterization extraction of eye blink is made from the original signal.

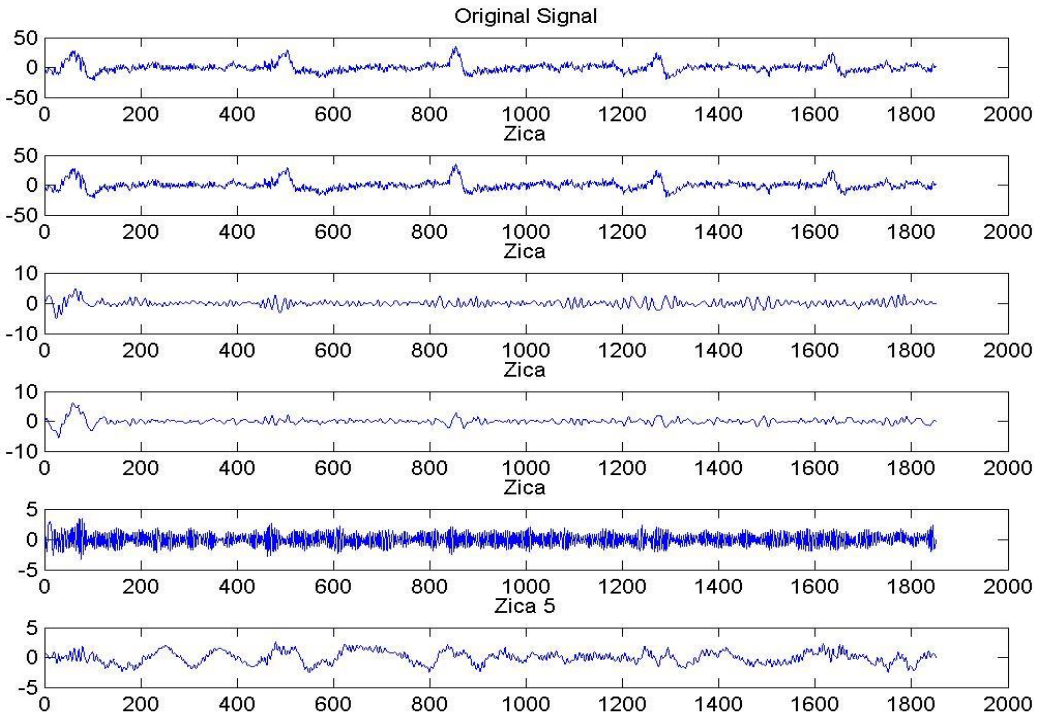

Fig 7. ICA output for first 5 IMFs

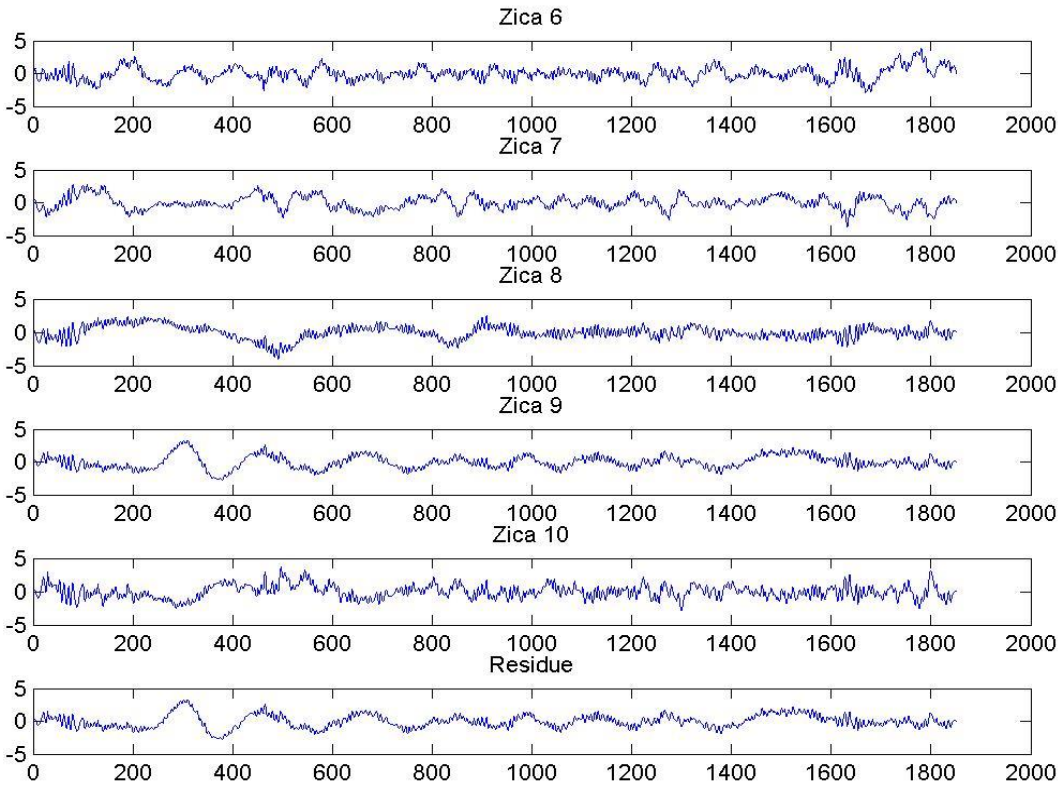

Fig 8. ICA output for next 5 IMFs

E)Result:

Input signal is read from the data set. This includes the noise so it requires to remove the noise. Noise free signal is passed to empirical mode operation. This will generates 10 IMFs. The IMF which is almost similar to input signal is passed to ICA by using IMF, ICA will suppresses signal. The suppressed signal is eye blink free EEG signal.

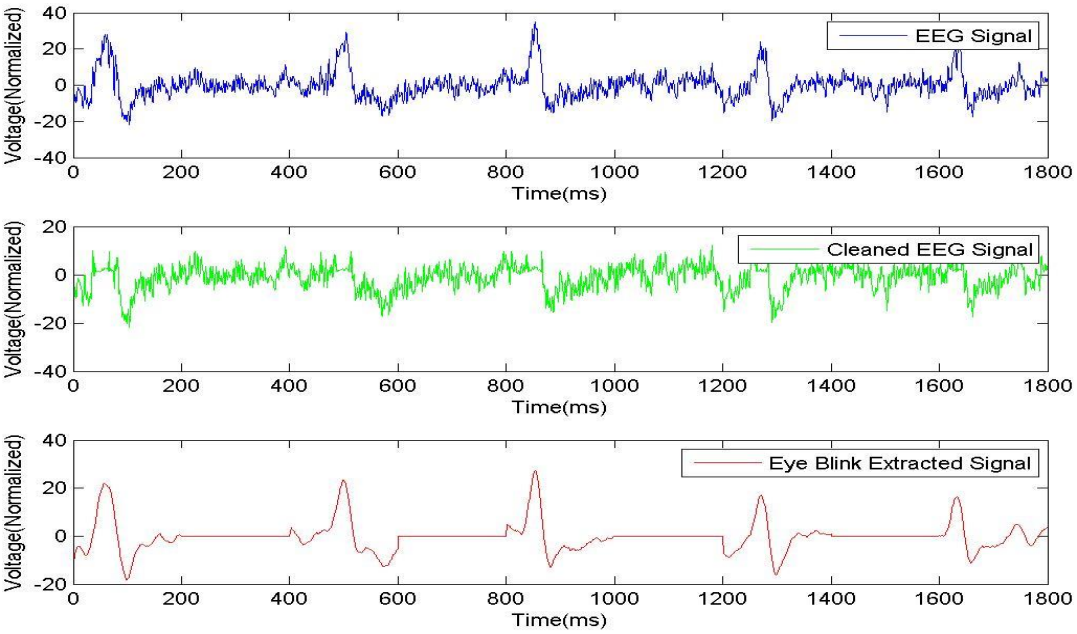

Fig 9. Extracted Eye blink with reconstructed signal.

After plotting the signal time v/s voltage, cross correlation is displayed on the command window. Cross-correlation coefficient was evaluated between each extracted template from the IMF and the corresponding artifact contaminated EEG segment. After the cross correlation the signal mean and signal standard of IMF is calculated, which displays correlation of IMF, Correlation of input, output , and this results in identification of cleaned EEG signal.

Table.1 . Comparisons of the correlation filter IMF, Signal means and Signal standard

Correfi IMF	Signal Mean	Signal STD
0.3087	**0.0409**	**2.2121**
-0.0869	**-0.0115**	**1.5945**
0.1035	**0.0137**	**1.3263**
0.5350	**0.0709**	**2.7600**
-0.2157	**-0.0286**	**1.7525**
-0.7580	**-0.1005**	**2.3538**
1.0661	**0.1413**	**3.1330**

V. SIGNIFICANCE AND LIMITATIONS

A) Significance:

Accuracy and efficiency can be enhanced using the proposed technology. A new approach for the elimination of the artifact due to eye-blinks from the contaminated EEG segment without using the reference electrode EOG data. It is easy to use. For different application like heart beat measurement , eye blink measurement and also for nerves measurement.

B)Limitation:

The suppression of the eye-blink signal from the contaminated EEG data. But it losses some data information's. Selected segments should not be contaminated by multiple artifacts.

VI. CONCLUSION

This project aimed at preprocessing the contaminated EEG signal into cleaned EEG signal. The methodology based on the operation is, here we are considering EEG signal with eye blink. In pre processing the records which are taken from the electrodes impose some amount of irrelevant noise contents in EEG data signals. The noise may be power biased noise and instrumentation noise. These noises are to be eliminated in pre processing itself before decomposition. The EMD technique is used to decompose the EEG signals into IMF's. The IMF's with eye blink signals are known as noisy IMF's those have to be removed using ICA. Independent component analysis (ICA) is used for the detection of the artifacts due to eye blink. Correlation is performed between extracted signal and original signal for validation. Input signal is read from the data set. This includes the noise so it requires to remove the noise. Noise free signal is passed to empirical mode operation. This will generates 10 IMFs. The IMF which is almost similar to input signal is passed to ICA by using IMF, ICA will suppresses signal. The suppressed signal is eye blink free EEG signal. The results of this project is to use of ICA and EMD has shown better performance in this field individually to yield the best performance as depicted in literature survey. The use of both EMD and IAC methods will enhance the accuracy of detection and suppression of eye blink signals from contaminated EEG dataset.

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